of the initial planting of much greater quantities of young plants to the acre. In any case, it seems clear that what may be reasonably close for ordinary conifers is unreasonably, and even disastrously, close for the quicker growing kinds.

P.S.—It may be convenient to append the table of plants required per acre (square planting).

3	feet apart	4840.	6½	feet apart	1031.
3½	,,	3556.	7	,,	889.
4	,,	2722.	7½	,,	774.
4½	,,	2151.	8	,,	680.
5	,,	1742.	8½	,,	603.
5½	,,	1440.	9	,,	537.
6	,,	1210.			

17. A New Disease of the Douglas Fir in Scotland.

(*With Plates.*)

By Malcolm Wilson, D.Sc. (Lond.), F.R.S.E., F.L.S., Lecturer in Mycology in the University of Edinburgh.

More than ten years ago my attention was directed by Dr A. W. Borthwick to specimens of the Douglas fir in which the leading shoot had been killed for a distance of 6-12 inches behind the apex. The trees were from 6-10 years old, and he suggested that the damage was not due, as was generally supposed, to frost. A few years later other similar specimens were received, and in these the fructifications of a species of *Phoma* were present on the dead shoots. Observations were then interrupted by the war, but during the last eighteen months numerous specimens have been obtained, many of them through the headquarters of the Forestry Commission in Scotland, and examination has shown that the disease is undoubtedly caused by a species of *Phomopsis*, a sub-genus of the large genus *Phoma*.

Specimens of the Douglas fir attacked by the disease have been received from several localities in Perthshire, from near Forres, and from Argyllshire, Dumfries and Inverness, and it may be concluded that the disease is widely spread in Scotland. The disease has been observed in trees up to about 10 years old, both in nursery stock and in plantations.

Two types of attack may be distinguished. In the first, the leading shoot (or occasionally a side shoot) is killed back for a variable distance, usually about 9 inches (Photos 1 and 2,

Plate IV.). In the second, the young tree is attacked a short distance above the ground-level, the outer tissues are killed either on one side only or completely round the stem, and ultimately the whole tree is killed (Plate V.). In both cases a very characteristic feature of the disease is the sudden decrease in diameter in passing from the healthy to the diseased portion of the stem, and this is very marked in the second method of attack described above, where the stem immediately above the diseased portion is abnormally increased in thickness. Numerous resin blisters are developed on the stem both above and below the point of attack (Photos 1 and 3), and after these have burst the whitish patches of dried resin are very obvious.

Some time after the stem is attacked, minute black fungus fructifications appear in large numbers on the dead portion, and in some cases on the dead leaves (Photo 2). These are at first covered, but are later on exposed by the splitting of the bark and finally project slightly above the surface. They contain very minute spores which in damp weather exude from the fructifications in mucilaginous filaments (Plate V., Fig. 4, *a*), or masses of whitish translucent appearance (Fig. 4, *b*, *c*).

It was at first believed that the disease is caused by the fungus *Phoma abietina*, first described by Hartig in Germany in 1889[1] as a parasite of the silver fir, on which it produces effects closely similar to those described above. This fungus has been stated by Böhm[2] to be the cause of a serious disease of the Douglas fir in Germany. It has also been recorded from France on the silver fir[3] and on a considerable number of different conifers in Denmark[4]. A careful examination of the Scottish specimens, however, shows that the fungus present differs from *Phoma abietina*, Hartig, in the shape and size of the spores and in the occurrence of a second kind of spore which has not been discovered in the fungus present on the silver fir. It also differs from *Phoma pithya*, Sacc., a species which has been confused with *Phoma abietina* but which is distinguished from the latter by the absence of definite sporophores. It is therefore proposed to give the name *Phomopsis Pseudotsugae* to

[1] Hartig, *Lehrbuch d. Baumkrankheiten*, 1889, p. 124.

[2] Böhm, *Zeitschr. f. Forst- u. Jagd-wesen*, 1896, p. 154.

[3] Prillieux et Delacroix, *Sur deux Parasites du Sapin pectiné*, etc. Bull. de la soc. mycologique de France, Tom. VI., 1890, p. 174-178.

[4] Lind, *Danish Fungi*, Copenhagen, 1913, p. 421.

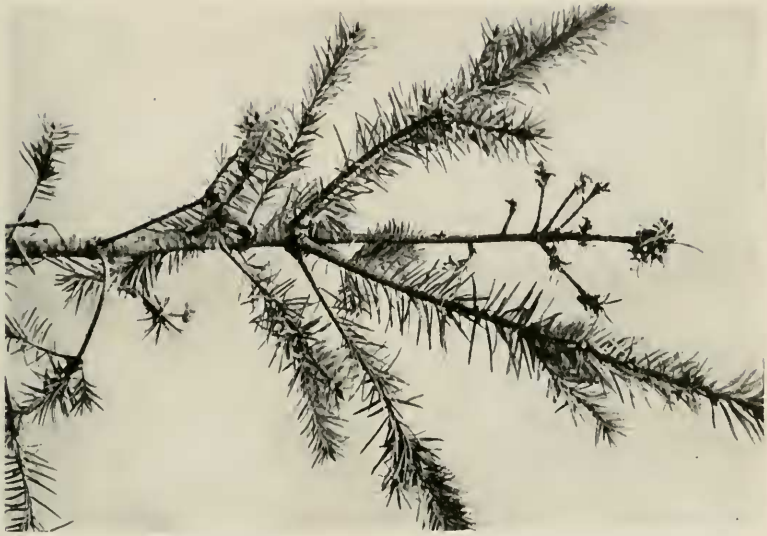

PHOTO 1.

PHOTO 2.

[*To face p.* 146.

PHOTO 3.

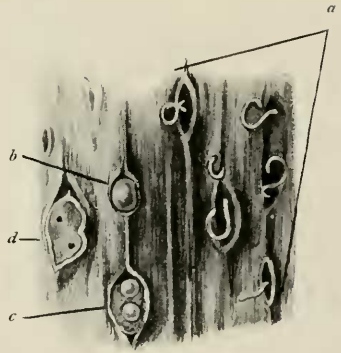

FIG. 4

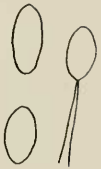

FIG. 6.

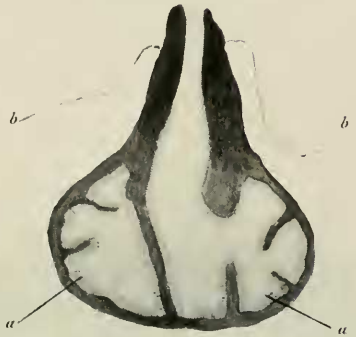

FIG. 5.

FIG. 7.

PLATE V.

the fungus found on the Douglas fir in Scotland. The description of the fungus is as follows[1]:—

Phomopsis Pseudotsugae, n.sp.

Pycnidia lens-shaped to conical, depressed and with a broader base, ·3-1 mm. broad, ·2-·5 mm. high, at first covered with the bark or leaf epidermis, later breaking through (in the case of the bark by an elongated slit) and projecting slightly, solitary or in groups of two, scattered, dull black and slightly roughened; texture everywhere several cells thick, more or less hyaline and tinged with green below, thicker and black above, opening with a definite ostiole; internal cavity partially divided up into several chambers by partitions greenish in colour and springing from the inner wall; spores hyaline, of two kinds—A-spores, elliptical-fusoid, obtuse at both ends, 5·5-8·5 × 2·5-4μ, without oil drops but with a minute granule towards one or both ends, with subulate sporophores about 13μ long; B-spores, rod-like generally curved, obtuse at each end without oil drops, 5-6 × 1·5μ with subulate sporophores 12-14 × 1-2μ.

The spores are shown in Figs. 6 (A-spores) and 7 (B-spores). The pycnidia containing A-spores are generally rather larger, often in groups of two, and have been found on the older parts of the host-plant, never on the leaves; only A-spores have been found on plants attacked near ground-level. Pycnidia containing B-spores are usually rather smaller, more decidedly conical, solitary, and have been found on both surfaces of the leaves, usually on the upper surface, and on the younger parts of the one-year old stems. Both kinds of spores emerge from the pycnidia in similar ways (Fig. 4). The sporophores usually remain inside the pycnidium attached to the walls and forming a distinct zone (Fig. 5, *a*). They are quite distinct in the young pycnidium, and can be seen attached to the spores (Figs. 6 and 7), but in the older pycnidia they appear to become mucilaginous and partially disintegrate.

A plantation of Douglas fir in Perthshire, about 6-8 years old, was examined in April of this year, and it was estimated that half of the trees had been killed by the disease. The dead trees were removed and burnt and the spaces were filled up by planting fresh trees. In September about 20 % of the trees were showing signs of attack, and these included some of those planted in the previous April.

[1] See also *Trans. Bot. Soc.*, Edin., vol. xxviii., pt. 1 (1920).

The method and time of attack are not yet fully known. Ripe spores capable of germination have been collected in April and October, and it is probable that infection takes place during the summer. In all probability the species is a wound parasite; this must certainly be the case where the main stem of plants, 4-8 years old, is directly attacked not much above ground-level, although it is possible that young uninjured shoots may become infected.

The narrowing of the stem in the infected portion is the result of the death of the cambium and consequent stoppage of secondary thickening. Probably some considerable time elapses between infection and death of the cambium. In the case of a tree 6-8 years old infected near the base, secondary thickening of the infected portion probably ceases about a year after infection when the leaves begin to turn yellow; death probably takes place during the following winter. In a tree in which the leading shoot is infected near the apex, growth continues during the following summer and death of the shoot takes place in the winter. Fructifications of the fungus are often found all over the dead trees, and it is evident that the fungus can live on as a saprophyte after the death of the tree.

From the above observations it may be concluded that *Phomopsis Pseudotsugae* is widespread in Scotland, and is probably increasing in abundance; it is doing very considerable damage to young plantations of the Douglas fir. At the present stage of our knowledge of the fungus little can be said as to prevention, but it is especially necessary to emphasise one point in this connection. Owing to the long period which elapses between infection and the first obvious signs of the disease, it is possible that nursery stock which is apparently healthy, although really diseased, may be planted out, and in this way the disease may be widely distributed. The following general precautions should be taken:—

(1) Young plantations should be carefully examined for trees showing the early signs of the disease, and these should be removed and burnt. All trees killed by the disease should be at once removed and burnt.

(2) Plantations, and especially nurseries, should not be established in areas known to be infected.

In conclusion, I wish to thank Miss L. Snelling for the drawing shown in Fig. 4, and Mr R. M. Adam for Photos 1, 2 and 3.

Explanation of Plates IV. and V.

All the photographs and figures refer to *Phomopsis Pseudotsugae*, n.sp., on *Pseudotsuga Douglasii*.

Photo 1. Four-year-old tree with leading shoot killed. About ½ nat. size.

Photo 2. Apical portion of dead leading shoot of a four-year-old tree; the pycnidia can be seen on the stem and leaves. About ¾ nat. size.

Photo 3. Four-year-old tree attacked near ground-level; resin blisters on bark above and below constricted portion. About ¾ nat. size.

Fig. 4. Portion of a young shoot showing pycnidia; *a*, A-spores in the form of mucilaginous tendrils emerging from several pycnidia; *b*, a single pycnidium from which a rounded mass of A-spores has just emerged; *c*, a group of two pycnidia from each of which a rounded mass of A-spores has emerged; *d*, a group of two empty pycnidia, each showing an ostiole (as a rounded black dot). × about 16 times.

Fig. 5. A pycnidium containing B-spores seen in longitudinal section (the spores are not shown); *a*, the layer of sporophores; *b*, outermost layer of bark. × about 35 times.

Fig. 6. A-spores, some still attached to sporophores. × 720.

Fig. 7. B-spores, some still attached to sporophores. × 720.

18. Notes on Jack Pines and Sitka Spruce.

(*With Plates.*)

By James Kay, B.Sc.F.

The three Jack pines are regionally distributed throughout Canada and the United States, and cover large areas of poor soils. This is due principally to their extreme hardiness, early and large seed production, and ability to seed up burned-over lands to the exclusion of more valuable species.

The three forms are :—

1. Eastern Jack Pine (*Pinus banksiana*), extending from Nova Scotia to the Rocky Mountains, and the valley of the M'Kenzie river, where it meets the lodgepole pine.

2. Lodgepole Pine (*Pinus contorta* var. *murrayana*), extending over the whole of British Columbia, from the Yukon territory in the north and the eastern slopes of the Rocky Mountains, and east to the Cypress Hills in Alberta.

3. Scrub Pine (*Pinus contorta*), found on the coast (Pacific), from the coast of Alaska to Northern California. It is usually found in sphagnum-covered bogs and the margins of deep wet swamps, but spreads inland and ascends the